



Finding Rank Orders of the Elementary Concepts of Arithmetic Used in I.C.S.E. Examination

Research Article

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Abstract: In this paper, an attempt has been made to find the rank orders of the identified top fifty eight elementary concepts of arithmetic which were used to solve the arithmetical problems of two years question papers of mathematics of Indian Certificate of Secondary Education (I.C.S.E.) Examination (2005 & 2006) of The Council for the Indian School Certificate Examinations (C.I.S.C.E.) through task analysis technique. The teachers as well as learners will be benefited in several ways like to diagnose the weakness of the students, to find the difficult order of these concepts, to emphasize on the learning of these concepts at appropriate grade levels etc. after knowing these elementary concepts. This study will help the entire curriculum development of school mathematics.

MSC: 97C99, 97D99, 97F99.

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1. Introduction

Arithmetic, the branch of mathematics, started from very early stage at school level for its social impact. The content of arithmetic has been introduced up to secondary level considering the objective of arithmetic teaching which is related to the basis of day to day real life need of the common people in such a way that the learners will become a good citizen in future. To achieve this objective, learners should have to well perform in arithmetic. But it is a fact that many learners are not able to solve the arithmetical problems of 10th standard Board examinations on account of their conceptual gaping.

The author is interested as a secondary level teacher to know which concepts are needed to solve those problems. If the learners as well as facilitator are acquainted with these types of concepts, then the hindrances to solve the problem may be overcome. So the author had stressed to identify the elementary concepts of arithmetic which were used to solve the arithmetical problems of mathematics of I.C.S.E. Examination and had already identified top thirty three elementary concepts and presented in (26).

But, in this paper, the author has found the rank orders of the identified total 58 elementary concepts which were used to solve the arithmetical problems of mathematics question papers in I.C.S.E. Examinations (2005 & 2006) through task analysis technique whereas he has identified total 9007 elementary concepts of arithmetic (24 & 25) through 'text book scanning process'(1 to 23) and 'task analysis technique'.

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2. Objective of the Study

To find the rank orders of the top fifty eight elementary concepts of arithmetic used in I.C.S.E. Examination (2005 & 2006) of C.I.S.C.E.

3. Definitions

3.1. Major Concepts and Sub-concepts

A major concept is an idea which is complete in itself and is comprehended through a sequential process of step-by-step partial comprehension of its related concepts. These related concepts are called sub-concepts which are not complete in itself but are parts of the major concept.

3.2. Elementary Concepts

A sub-concept which can not be split further will be called an 'elementary concept'.

4. Materials and Methods

It has been done in several stages

- i. The two years question papers of mathematics of I.C.S.E Examination (2005 & 2006) have been collected for studying the major concepts of mathematics at secondary level through the task analysis technique.
- ii. All the items of arithmetic which are relevant to our major concept analysis of the said question papers have been solved in such a way that a student may get full mark on each item. All the methods have been considered here where a sum has been solved more than one method.
- iii. Then the answer scripts of the said question papers were given to some expert examiners to examine. They also have suggested some alternative methods or techniques to solve some items.
- iv. The answer scripts have been re-written incorporating the views of the expert examiners.
- v. All the details of the solutions have been worked out (analysed in detail up to elementary level concepts) to find out all possible elementary concepts with their frequencies of occurrences which have been used in the solutions.
- vi. In this phase of detail-analysis, again experts' opinions were sought and their opinions were incorporated. Then final form of the solutions for each items have been prepared.
- vii. The elementary concepts which have been used in the solutions of each item have been identified and separated.
- viii. Now the frequency of elementary concept of the item is the total number of elementary concept used to solve the sum in a single method. In case where a particular item has been solved in more than one method, the number of elementary concepts used and their frequency have been determined by using the following criteria: All the elementary concepts used in different methods have been selected and maximum frequency of each elementary concept within different methods has been taken as the frequency of that concept.
- ix. Then elementary concepts which are used in I.C.S.E. Examination (2005 & 2006) were counted.

- x. Top fifty eight frequently used elementary concepts determined by their frequency of use of arithmetic of I.C.S.E. Examination (2005 & 2006) have been identified.
- xi. The rank orders of these elementary concepts according to their frequency of use have been determined.
- xii. The elementary concepts among the identified elementary concepts which were not included in the prescribed text books of N.C.E.R.T. have been identified.

5. Major Findings

Using the above method, top fifty eight elementary concepts according to its frequency of use in arithmetic of I.C.S.E. Examination (2005 & 2006) of C.I.S.C.E. have been identified whereas top thirty three of them had been already presented before (26). Now these fifty eight elementary concepts, their frequency of use and the rank order have been presented below in column 2, 3 and 4 of Table-1 respectively. For better understanding of these elementary concepts, Question (Q) is given in almost all concepts in column 2 of the Table-1. Here, in column 5 of Table-1, the symbol '*' represent the concepts which had not been included in the prescribed text books of mathematics of N.C.E.R.T.

Table 1. Rank orders of elementary concepts of arithmetic according to frequency of use in arithmetic problems of I.C.S.E. Examination

1	2	3	4	5
Sl. No.	Name of the elementary concept	Frequency of use	Rank	symbol
1.	Vertical multiplication where both multiplicand and multiplier are one-digit numbers. Q. Multiply: i) $\begin{array}{r} 4 \\ 3 \end{array}$ ii) $\begin{array}{r} 8 \\ 6 \end{array}$	113	1	*
2.	Addition of two one-digit numbers, one of them must be zero (vertical addition). Q. Add: i) $\begin{array}{r} 2 \\ 0 \end{array}$ ii) $\begin{array}{r} 0 \\ 0 \end{array}$	110	2	
3.	Horizontal multiplication where both multiplicand and multiplier are one-digit numbers. Q. Multiply: i) 3×2 (ii) 5×8	92	3	
4.	Addition of two one-digit numbers, one of them must be zero (horizontal addition) Q. Add: i) $4 + 0$ ii) $0 + 7$	57	4	*
5.	Vertical subtraction carryover where minuend is two-digit number and subtrahend is two-digit number Q. Subtract: $\begin{array}{r} 63 \\ 39 \end{array}$	40	5	
6.	Vertical subtraction where minuend is one-digit number and subtrahend is zero. Q. Subtract: i) $\begin{array}{r} 7 \\ 0 \end{array}$ ii) $\begin{array}{r} 0 \\ 0 \end{array}$	37	6	
7.	Vertical addition of two one-digit numbers except zero (without activities) where the numbers are in numeral form. Q. Add: $\begin{array}{r} 3 \\ 3 \end{array}$	33	7	
8.	Vertical subtraction without carryover where minuend is three-digit number and subtrahend is three-digit number. Q. Subtract: $\begin{array}{r} 575 \\ 332 \end{array}$	31	8	
9.	Vertical multiplication where multiplicand is one-digit number and multiplier is zero. Q. Multiply: $\begin{array}{r} 5 \\ 0 \end{array}$	26	9	*
10.	Vertical addition of two one-digit numbers where the sum is two-digit number (addition only). Q. Add : $\begin{array}{r} 8 \\ 7 \end{array}$	25	10	
11.	Horizontal subtraction where minuend is one-digit number and subtrahend is zero (subtraction only). Q. Subtract: i) $7-0$ ii) $0-0$	24	11	
12.	Horizontal multiplication where multiplicand is one-digit number and multiplier is zero. Q. Multiply: 9×0	20	12	

1	2	3	4	5
Sl. No.	Name of the elementary concept	Frequency of use	Rank	symbol
13.	Vertical multiplication without carryover where multiplicand is three-digit number and multiplier is one-digit number where the product is three-digit number (multiplication only). Q. Multiply: $\begin{array}{r} 204 \\ \times 2 \\ \hline \end{array}$	16	13	
14.	Horizontal subtraction where minuend is one-digit number and subtrahend is same as minuend (subtraction only). Q. Subtract: $3 - 3$	14	14	
15.	Vertical subtraction where minuend is one-digit number and subtrahend is one-digit number where the remainder is one-digit number except zero (subtraction only). Q. Subtract: $\begin{array}{r} 4 \\ \times 2 \\ \hline \end{array}$	13	17	
16.	Vertical subtraction where minuend is one-digit number and subtrahend is same as minuend. Q. Subtract: $\begin{array}{r} 8 \\ \times 8 \\ \hline \end{array}$	13	17	*
17.	Horizontal addition of two one-digit numbers except zero where the sum is one-digit number. Q. Add: $2 + 1$	13	17	
18.	Vertical multiplication without carryover where multiplicand is two-digit number and multiplier is one-digit number where the product is three-digit number (multiplication only). Q. Multiply: $\begin{array}{r} 21 \\ \times 7 \\ \hline \end{array}$	13	17	
19.	Fraction is expressed with 100 as denominator the word percent to describe it and its symbol is %. Q. Write the following as a fraction with 100 as denominator. 9% (A: $\frac{9}{100}$)	13	17	
20.	Changing a percentage into a fraction with lowest terms. Q. Express the following as a fraction with the lowest terms. 25% (A: $25\% = 25/100 = 1/4$)	11	20	
21.	Division having no remainder where dividend is one-digit number and divisor is one-digit number (where the sum is in horizontal form). Q. Divide: $8 \div 4$	10	24	
22.	Division having no remainder where dividend is one-digit number and divisor is one-digit number (where the sum is in fractional form). Q. Divide: $\frac{9}{3}$	10	24	*
23.	Division having no remainder where dividend is one-digit number and divisor is one-digit number (where the sum is in working form). Q. Divide: $2 \overline{)6}$	10	24	*
24.	Expression of whole number into fractional form of different denominators. Q. Express 7 into fractional form of different denominators. (A: $\frac{7}{1}, \frac{14}{2}, etc$)	10	24	
25.	Multiplication of a whole number by a proper fraction. Q. Multiply: $8 \times 3/4$	10	24	
26.	Fractions in lowest terms. Q. Which of the fractions is in the lowest term? $\frac{3}{6}, \frac{1}{2}, \frac{2}{4}$ (A: $\frac{1}{2}$)	10	24	
27.	Simplifying a fraction. Q. Simplify: $\frac{1225}{900}$	10	24	
28.	Vertical multiplication with carryover where multiplicand is two-digit number and multiplier is one-digit number where the product is three-digit number (multiplication only). Q. Multiply: $\begin{array}{r} 97 \\ \times 9 \\ \hline \end{array}$	9	28	
29.	Horizontal addition without carryover where one addend is two-digit number and other is single digit number. Q. Add: $24 + 3$	8	31	
30.	Horizontal addition without carryover where one of the addends will be five-digit or six-digit number. Q. Add: $35724 + 33$	8	31	
31.	Horizontal subtraction with carryover where minuend is five or six-digit number and subtrahend is up to five or six-digit number respectively: expression of the problem in mathematical language. Q. Express the following mathematical problem horizontally. There were 58674 hens in a poultry firm. 1895 among them were dead for certain diseases. How many hens were left in the poultry firm? (A: $58674 - 1895 = ?$)	8	31	*
32.	Vertical subtraction with carryover where minuend is five or six-digit number and subtrahend is up to five or six-digit number respectively: expression of the problem in mathematical language. Q. Express the following mathematical problem vertically. There were 58674 hens in a poultry firm. 1895 among them were dead for certain diseases. How many hens were left in the poultry firm? $\left(\begin{array}{r} 58674 \\ A : \underline{-1895} \\ \hline ? \end{array} \right)$	8	31	*
33.	Division having no remainder where dividend is five-digit number and divisor is three-digit number: division after transformation from fractional form to working form. Q. Divide after transformation from fractional form to working form. $\frac{90628}{278}$	8	31	*

1	2	3	4	5
Sl. No.	Name of the elementary concept	Frequency of use	Rank	symbol
34.	Vertical subtraction of whole numbers carryover where minuend is five or six-digit number and subtrahend is at least one-digit number less than the minuend. Q. Subtract: $\begin{array}{r} 45786 \\ - 7878 \\ \hline \end{array}$	7	35.5	
35.	Division having no remainder where dividend is five-digit number and divisor is three-digit number (where the sum is in working form). Q. Divide: $278 \overline{)90628}$	7	35.5	*
36.	Division having no remainder where dividend is five-digit number and divisor is three-digit number: division after transformation from horizontal form to working form. Q. Divide after transformation from horizontal form to working form. $90628 \div 278$	7	35.5	
37.	Vertical multiplication where multiplicand is five-digit number and multiplier is one-digit number. Q. Multiply: $\begin{array}{r} 74859 \\ \times 8 \\ \hline \end{array}$	7	35.5	*
38.	Horizontal subtraction of whole numbers where minuend is one-digit number and subtrahend is one-digit number where the remainder is one-digit number except zero Q. Subtract: $5 - 3$	6	44.5	
39.	Subtraction after transformation from horizontal form to vertical form carry over where minuend is five or six-digit number and subtrahend is at least one-digit number less than or equal to the minuend. Q. Subtract: i) $86559 - 78639$ ii) $785632 - 67$	6	44.5	
40.	Vertical subtraction of whole numbers carryover where minuend is five or six-digit number and subtrahend is five or six-digit number respectively. Q. Subtract: $\begin{array}{r} 45786 \\ - 17878 \\ \hline \end{array}$	6	44.5	
41.	Division without carry over having no remainder where dividend is two-digit number and divisor is one-digit number (where the sum is in horizontal form). Q. Divide: $65 \div 5$	6	44.5	
42.	Division without carry over having no remainder where dividend is two-digit number and divisor is one-digit number (where the sum is in fractional form). Q. Divide: $\frac{25}{5}$	6	44.5	*
43.	Division without carry over having no remainder where dividend is two-digit number and divisor is one-digit number (where the sum is in working form). Q. Divide: $9 \overline{)36}$	6	44.5	*
44.	Division having no remainder where dividend is two-digit number and divisor is two-digit number (dividend \geq divisor) (where the sum is in working form). Q. Divide: $13 \overline{)65}$	6	44.5	*
45.	Division having no remainder where dividend is two-digit number and divisor is two-digit number (dividend \geq divisor): division after transformation from horizontal form to working form. Q. Divide after transformation from horizontal form to working form. $48 \div 12$	6	44.5	
46.	Division having no remainder where dividend is two-digit number and divisor is two-digit number (dividend \geq divisor): division after transformation from fractional form to working form. Q. Divide after transformation from fractional form to working form. $\frac{77}{11}$	6	44.5	*
47.	Vertical multiplication without carryover where multiplicand is two-digit number and multiplier is one-digit number where the product is two-digit number. Q. Multiply: $\begin{array}{r} 22 \\ \times 3 \\ \hline \end{array}$	6	44.5	
48.	Vertical multiplication carryover where multiplicand is three-digit number and multiplier is one-digit number where the product is four-digit number. Q. Multiply: $\begin{array}{r} 978 \\ \times 9 \\ \hline \end{array}$	6	44.5	
49.	Vertical multiplication without carryover where multiplicand is three-digit number and multiplier is one-digit number where the product is four-digit number. Q. Multiply: $\begin{array}{r} 634 \\ \times 2 \\ \hline \end{array}$	6	44.5	
50.	Decimals and whole numbers. Q. Write the whole number into decimal. 2	6	44.5	*
51.	Concept of round off of decimals: for fractional or decimal form up to certain digit: writing in round off form. Q. Express $\frac{23}{41}$ into round off form up to 2, 3 decimal places.	6	44.5	*
52.	Horizontal multiplication carryover where multiplicand is two-digit number and multiplier is one-digit number where the product is three-digit number. Q. Multiply: 99×8	5	55	*
53.	Vertical multiplication without carryover where multiplicand is two-digit number and multiplier is one-digit number where the product is two-digit number. Q. Multiply: 33×3	5	55	*
54.	Horizontal multiplication carryover where multiplicand is three-digit number and multiplier is one-digit number where the product is four-digit number. Q. Multiply: 596×8	5	55	*
55.	Horizontal addition of like decimals (up to two decimal places) where the addends involving mixed decimal. Q. Add: $2.5 + 2.4$	5	55	*
56.	Vertical addition of rupees and paise with decimal system. Q. Add: $\begin{array}{r} Rs.4.75 \\ + Rs.3.95 \\ \hline \end{array}$	5	55	
57.	Finding L.C.M. of two whole numbers where both numbers are below or equal to 20 using prime factorization method. Q. Find the L.C.M of 4 & 12 using prime factorization method.	5	55	
58.	Finding L.C.M. of two whole numbers where both numbers are below or equal to 20 using common division method. Q. Find the L.C.M of 4 & 12 using common division method.	5	55	*

In the above table-1, first fourteen elementary concepts, the elementary concepts of sl. nos-20 and 28 out of fifty eight elementary concepts which have different frequency of use and rank orders. The elementary concept sl. nos. from 15 to 19, each of their frequency of use is 13 and rank order 17, elementary concept sl. nos. from 21 to 27, each of their frequency of use is 10 and rank order is 24, concept nos. from 29 to 33, each of their frequency of use is 8 and rank order is 31, concept nos. from 34 to 37, each of their frequency of use is 7 and rank order is 35.5, concept nos. from 38 to 51, each of their frequency of use is 6 and rank order is 45.5, concept nos. from 52 to 58, each of their frequency of use is 5 and rank order is 55.

6. Conclusion

- i. This methodology helps to identify the elementary concepts of arithmetic which are used to solve the mathematical problems of different Board examination.
- ii. Table-1 reveals the rank orders of Identified top fifty eight elementary concepts of arithmetic according to frequency of use in two years mathematics question papers of I.C.S.E. Examination (2005 & 2006) have been presented. It may be said that a large number of elementary concepts that they have same importance according to their rank orders.
- iii. This study will help to identify the weakness of the students after taking an investigation those students who are going to appear the ICSE Examination.
- iv. Total twenty two elementary concepts (which have been mentioned in the major findings) out of fifty eight used in I.C.S.E. Examination (2005 & 2006) had not been taken into consideration in the prescribed text books of mathematics of N.C.E.R.T. So it should be included in the prescribed text books of mathematics for the entire curriculum development of mathematics teaching to meet the needs of the learners.
- v. The teachers as well as learners will also be benefited in several ways like to diagnose the weakness of the students, to find the difficult order of these concepts, to emphasize on the learning of these concepts at appropriate grade levels etc. after knowing these elementary concepts.
- vi. Learners should be properly acquainted with these elementary concepts at the appropriate level which will help to perform better at the 10th standard Board examination.

7. Further Study

- i. To identify the order of difficulty of the top fifty eight elementary concepts of arithmetic among the 10th standard learners.
- ii. To diagnose the weakness of the learners in the top fifty eight elementary concepts of arithmetic.

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